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COORDINATED EGG PRODUCTION AND MARKETING IN THE NORTH CENTRAL STATES

V. LEAST-COST EGG MARKETING ORGANIZATION UNDER ALTERNATIVE PRODUCTION PATTERNS

RESEARCH BULLETIN 547

Agricultural Experiment Stations of Alaska, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin, and the U.S. Department of Agriculture cooperating.

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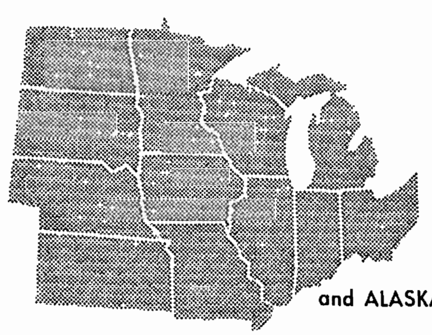

and ALASKA

FOREWORD

This report is the fifth in a series being published as part of the North Central Regional Project NCM-31, "Coordinated Egg Production—Marketing Programs and New Marketing Technology." This is a cooperative study involving Agricultural Experiment Stations in the North Central Region and agencies of the U. S. Department of Agriculture. All agencies contribute personnel, funds, or both to this research program.

Representatives from the following states and federal agencies participated in this study.

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This series of reports is concerned with the economics of coordination in the egg industry in the North Central States. The reports will cover the following facets of coordinated programs:

I. Kinds of Programs
II. Characteristics and Attitudes of Independent and Contract Egg Producers
III. Egg Products—Contractual Agreements and Procurement Methods
IV. Production Inputs—Feed Mills and Hatcheries
V. Shell Egg Procurement and Processing
VI. Owner-Integrated, Direct Marketing
VII. Egg Distribution

CONTENTS

Coordinated Egg Production and Marketing in the North Central States-V. Least-cost Egg Marketing Organization Under Alternative Production Patterns[1]

by Bernard L. Sanders and Lehman B. Fletcher[2]

Important changes are taking place in the midwestern egg industry. Changes in Iowa are broadly representative of the transformations taking place in this industry throughout the region. One of the most significant changes has been the decline in the number of farms producing eggs. In 1940, 198,000 Iowa farms —or 93 percent of all farms—reported chickens on hand. In 1950, the number was 174,000, or 86 percent. By 1959, there had been a further decline to 68 percent.

Along with the changing number of farms producing eggs, there has been a change in the sizes of flocks on farms. In Iowa, the proportion of very small flocks has remained nearly constant. In 1940 and 1950, roughly 13 percent of all Iowa flocks had fewer than 50 hens. This rose to about 15 percent in 1959. A sharp decline in medium-sized flocks of 50 to 400 hens occurred in the same period, from 86 percent in 1940 to 71 percent in 1959. Numbers of flocks larger than 400 hens have shown substantial increases, as shown in table 1 (1, 8, 14).

Small flocks (less than 50 hens) are of little commercial importance. They are maintained mainly to supply the farm household with eggs for consumption. Farm flocks of 50 to 400 hens are most numerous; they have served as a means of acquiring a steady flow of cash for the household and an outlet for family labor on the family farm. For our study, flocks of this size take on great importance; they are the main component of the existing production pattern. Flocks larger than 400 hens are increasing rapidly and will probably continue to increase because of economies of scale in egg production and possible economies in marketing operations. This study emphasizes these larger flocks to ascertain their relationship to assembly and processing costs.

Also important to regional analysis, is that Iowa produces more surplus eggs than any other state in the nation. More than 10 million cases of eggs (or 83 percent of production) were shipped to deficit markets in 1961. This makes Iowa an important source of eggs for these areas, principally in the East. Important changes in recent years, however, have endangered Iowa's and the Midwest's position of supplying outside markets. California and some of the southeastern states, principally North Carolina, South Carolina, Georgia, Alabama and Mississippi, have changed from deficit to surplus production.

Production changes in such regions mean stiffer competition in deficit markets and, possibly, the eventual loss of these markets.

Also, if the egg industry is to remain profitable in Iowa, incomes generated in the industry must be comparable to incomes in other enterprises in which the same inputs can be used. One way to accomplish this is to reduce production and marketing costs. Producers in the egg industry can then remain competitive with the other surplus-producing regions by getting their product to the deficit markets at least cost. To do this, more efficient production practices and flock sizes, assembly operations, handling practices and distribution patterns would have to be developed. Incomes would also be improved by reducing the cost of major production inputs. This would involve improvements in efficiency in the input-supplying plants and the distribution of the inputs to the egg producers. Our study concentrates on improving the efficiency of the assembly and processing stages. This study, then, analyzes the effects of specific factors on the optimum marketing organization of Iowa's egg processing industry.

Egg processing is defined here as the grading, sizing and packing of shell eggs for consumption. Optimum marketing organization is defined as the number, size and location of egg processing plants that minimize the combined assembly and processing costs. The factors analyzed for their effect on assembling and processing costs are: 1) the number and organization of processing plants and 2) the level and pattern of pro-

Table 1. Number of Iowa farms reporting chickens on hand, by size of flock, 1940, 1950, 1954 and 1959.

Flock sizes	1940	1950	1954	1959
400 – 799	3,419	5,397	12,664	14,134
800 – 1,599	116	345	1,067	2,254
1,600 – 3,199	15	67	122	407
3,200 & over	2	20	26	108
3,200 – 6,399	0	0	0	77
6,400 – 9,999	0	0	0	22
10,000 & over	0	0	0	9

Source: Buche (1), Mortenson (8) and U. S. Bureau of Census (14).

[1] Professor Lee Bawden, University of Wisconsin, Professors Richard G. Heifner and Henry E. Larzelere, Michigan State University and George Rogers, Marketing Economics Division, U.S.D.A., reviewed the manuscript and made important contributions to it. The final draft is the responsibility of the authors.

[2] Instructor and professor, respectively, Department of Economics, Iowa State University.

duction. Pattern of production includes the number of producers, size distribution of flocks and the density of production. Although the specific concern of this study is with Iowa conditions, the concepts and functional relationships used are applicable to other states in the region.

The following specific factors are analyzed: 1) automatic and semi-automatic plant equipment, 2) scale of processing plants, 3) single- and double-shift operation of processing plants, 4) plant operations of 80 percent of eggs cartoned with 20 percent case-packed and 70 percent cartoned with 30 percent case-packed, 5) truck sizes ranging from 100 cases to 250 cases, 6) once- and twice-per-week assembly, 7) flocks ranging from the existing sizes to 20,000 layer flocks, 8) various locations for processing plants and 9) changes in production density.

By varying these factors, a least-cost solution in terms of the number, size and location of egg processing plants was found for a 13-county area in central Iowa.

A one double-shift plant located at Webster City was the least-cost solution when existing production pattern and semi-automatic equipment were used. The plant processed an annual volume of 1,331,512 cases. This solution had an average cost of $2.212 per case for assembling and processing. When automatic equipment was used, the least-cost solution was the same but with an average cost of $2.131.

Increases in truck sizes used in the assembly operation decreased costs of assembly. Changes in the flock size also had a significant effect on the assembly costs. As flock sizes became larger, assembly costs decreased. The most significant reduction occurred in flock sizes ranging up to 5,000 layers.

All least-cost solutions involved only one plant, except where assembly was on a twice-a-week basis with the existing production pattern. The least-cost solution then was two double-shift plants located at Clarion and Boone. These plants processed annual volumes of 676,271 and 655,241 cases, respectively.

OBJECTIVES, MODEL AND RESEARCH PROCEDURE

Objectives

Because of the rapid changes now taking place in the egg industry in general and Iowa's egg industry in particular, many problems are arising that need answers. A general problem is the changes that will or should take place in egg assembly and processing operations to meet egg production changes.

Are existing plants economical? Are there too many or too few plants for future needs? Should outdated plants remain in use, be remodeled and enlarged, or be abandoned? If a new plant is to be built, what equipment should be used? Where should it be located? What capacity should it have?

In assembly operations, what size truck should be used? How large a supply area can economically be served? Should the assembly truck stop at every producer regardless of size—or pick up only from larger producers?

Other questions involve such things as quality control, integration and processing at the location of production.

These are only a few of the many problems. This study will attempt to provide information about some of them. To do this, the following main objectives were chosen for this study:

1) To determine the effects of various factors on the least-cost number, size and location of processing plants.

2) To determine the cost differences, in assembling and processing eggs, resulting from the various factors.

Several subobjectives were also established:

a) To determine the relationship between size of assembly truck and assembly costs.

b) To determine the relationship between assembly costs and frequency of egg collection.

c) To determine the relationship between assembly costs and number of plants.

d) To determine the relationship between processing costs and volume of processing for single- and double-shift operations.

e) To determine the relationship between processing costs and number of plants.

f) To determine the least-cost number, size and location of egg processing plants for the existing production patterns and density.

g) To determine the effect of varying the production pattern on the least-cost solution.

Model

The general model used to determine the optimum number, size and location of processing plants was developed by Stollsteimer (12). The analytical model requires statements defining the relationship between assembly and processing costs and the number of plants, given a fixed volume of output. It also requires statements defining the relationship between assembly and processing costs and the volume of output.

Stollsteimer (12) defines the assembly cost function as

$$\underset{(J,L_K)}{TAC} = \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij}C_{ij} \mid L_J$$

and the total processing cost function as

$$\underset{(J,L_K)}{TPC} = \sum_{j=1}^{J} P_jX_j \mid L_J.$$

The combined total cost function is stated as

$$TC = \sum_{(J,L_K)\ j=1}^{J} P_j X_j \mid L_J + \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} \mid L_J$$

with respect to plant numbers (J), where $J \leqq L$, and locational pattern (L), where

$$L_K = 1, 2, \ldots, \binom{L}{J}.$$

This is subject to the following constraints:

$$\sum_{j=1}^{J} X_{ij} = X_i;\ i = 1, 2, \ldots, I$$

$$\sum_{i=1}^{I} X_{ij} = X_j;\ j = 1, 2, \ldots, J$$

$$\sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} = X$$

$$X_{ij} \geqq 0;\ i = 1, 2, \ldots, I;\quad j = 1, 2, \ldots, J$$

$$X_j \geqq 0;\ j = 1, 2, \ldots, J$$

$$X_i \geqq 0;\ i = 1, 2, \ldots, I$$

The problem, then, is to minimize TC, the total combined processing and assembly cost function when given I raw material origins, each producing specified quantity X_i of the raw material to be assembled and processed at one of the L possible processing plant locations. The following definitions will further explain the model:

TC = total combined processing and assembly costs.
TAC = total assembly costs.
TPC = total processing costs.
X = total quantity of raw material produced.
L_K = one combination of locations for J plants among the $\binom{L}{J}$ possible combinations of locations for J plants.
L_J = all combinations of locations for J plants.
L_j = location of plant j.
P_j = unit processing cost at plant j.
X_j = quantity of raw material processed at plant j.
X_i = quantity of raw material produced at origin i.
X_{ij} = quantity of raw material assembled at origin i and transported to plant j.
C_{ij} = unit cost of assembling the raw material at origin i and transporting to plant j.

Some assumptions are necessary to make the model operational. The assumptions concerning the processing cost function are: 1) the total long-run processing cost function in relation to volume of output is linear and positively sloping with a positive intercept (i.e., long-run marginal costs are constant), 2) economies of scale exist throughout and are never exhausted, 3) processing costs are independent of plant location and 4) processing technology remains unchanged.

For the purposes of this study, a constant cost for assembly within the given routes was added to the total assembly cost function. This constant factor is denoted as $\sum_{i=1}^{I} C_m$ where C_m is the fixed within-route cost of assembly for county m ($m = 1, \ldots M$). This cost factor varies for each of the m counties depending on the pattern and density of production within that county. This changes the total assembly cost function to

$$TAC = \sum_{(J,L_K)\ i=1}^{I} C_m + \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} \mid L_J$$

and the total combined cost function to

$$TC = \sum_{(J,L_K)\ j=1}^{J} P_j X_j \mid L_J + \sum_{i=1}^{I} C_m + \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} \mid L_J$$

Also, X_i, the quantity of raw material produced at origin i, is a constant quantity for all i, depending on the given size of each origin.

The first step in minimizing the combined total cost function with respect to plant number (J) and locational pattern (L_K) is to obtain an assembly cost function that has been minimized with respect to plant locations with varying numbers of plants (J). There are $\binom{L}{J}$ possible combinations of locations $L_K \mid J$. For each possible locational pattern, L_K, there is a submatrix, $C^*_{ij} \mid L_K$, of the transportation cost matrix (C_{ij}). The submatrix, $C^*_{ij} \mid L_K$, will be of size $(I \times J)$ with the entries in each element of the matrix representing the per-unit assembly cost from each origin to each particular plant site. An $(I \times 1)$ vector $\overline{C}_{ij} \mid L_K$ is obtained by scanning $C^*_{ij} \mid L_K$ by rows and selecting the minimum C_{ij} in each row. Minimum total assembly costs, with J plants and a fixed locational pattern L_K, are equal to the product of the $(1 \times I)$ vector X', with all entries equal to the fixed value of X_i, and the $(I \times 1)$ vector $\overline{C}_{ij} \mid L_K$, plus the fixed within-route cost factor $(\sum_{i=1}^{I} C_m)$.

This can be expressed as

$$(X'_i)\overline{C}_{ij} \mid L_K + \sum_{i=1}^{I} C_m.$$

For each value of J there are $\binom{L}{J}$ such values. The minimum of these values over L_K is a point on the assembly cost function minimized with respect to plant locations.

We then have J values of the following function

$$\overline{TAC} \mid J = L_K^{min} (X'_i)\ \overline{C}_{ij} \mid L_K + \sum_{i=1}^{I} C_m$$

where

$\overline{TAC}$ = total assembly cost minimized with respect to plant location for each value of $J = 1, \ldots L$,

(X'_i) = a $(1 \times I)$ vector containing elements equal to the fixed value of X_i,

$\overline{C}_{ij} \mid L_K$ = an $(I \times 1)$ vector whose entries C_{ij} represent minimized unit transfer costs between each origin and a specified set of locations (L_J) for J plants,

and

$\sum_{i=1}^{I} C_m$ = the sum of the fixed within-route assembly costs.

As plant numbers (J) vary, the shape of the total assembly cost function minimized with respect to plant locations may be deduced from the expected signs of the first and second differences of $\overline{TAC}$ with respect to (J). Stollsteimer (13) shows that the first difference will be negative or zero; that is,

$$\frac{\Delta \overline{TAC}}{\Delta J} \leqq 0$$

and it will be less than zero as long as there exists an entry C^{**}_{ij} which is not in $\overline{C}_{ij} \mid L_K$ such that $C^{**}_{ij} \mid \overline{C}_{ij}$ for some i.

The second difference will be positive or zero, that is

$$\frac{\Delta^2 \overline{TAC}}{\Delta J^2} \geqq 0$$

and in all empirical applications studied, it was positive. This yields a total assembly cost function of the form illustrated in fig. 1. This function is the envelope curve of the set of total assembly cost curve points. The number of such points is equal to $\sum_{J=1}^{L} \binom{L}{J}$ with $\binom{L}{J}$ points rising vertically above the total assembly cost function for each value of J.

The next step is to define the relationship between total processing costs and the number of plants. This has been defined as

$$\underset{(J, L_K)}{TPC} = \sum_{j=1}^{J} P_j X_j \mid L_K.$$

To find this relationship we can use the total processing cost curve with respect to volume, which is assumed linear and positively sloping with a positive intercept. This is shown in fig. 2.

Since the total quantity of raw material (X) is fixed, the total processing cost when one firm is processing all the raw material will be equal to $(a + bX)$ where (a) is the intercept value and (b) is the slope of the total processing cost function. As the number of plants increases, the total processing cost curve with respect to plant numbers will increase for each additional plant by an amount equal to the minimum average annual long-run cost of establishing and maintaining a plant. This is because of the assumption of constant and equal marginal costs for all plant sizes. Thus, the minimum average annual long-run cost of establishing and maintaining a plant is equal to (a), the intercept value of the total processing cost function with respect to volume. We can then graph the total processing cost curve with respect to plant numbers (fig. 3).

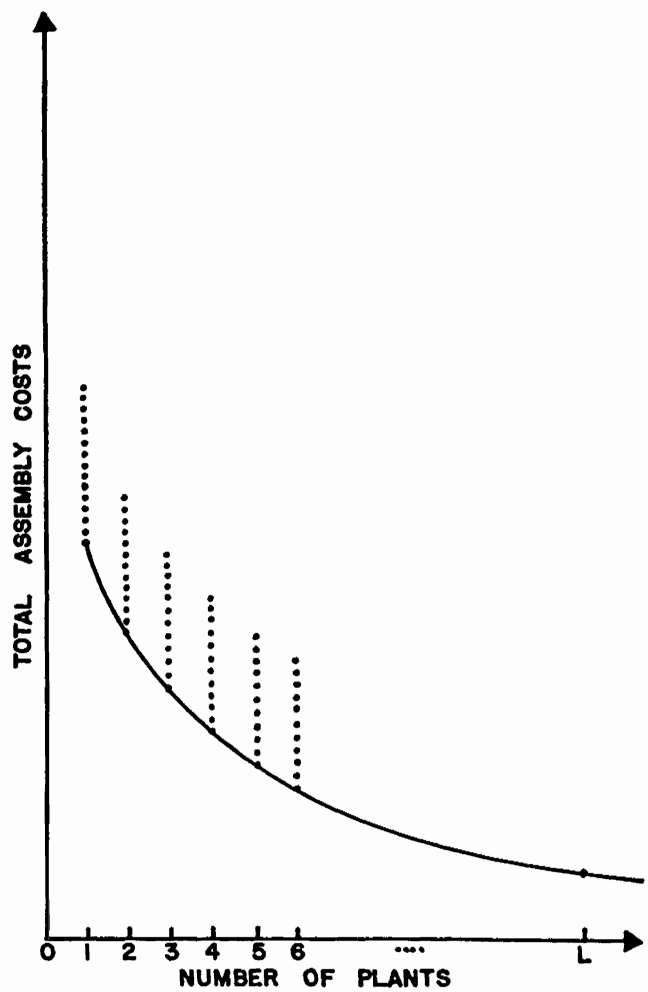

Fig. 1. Total assembly cost function.

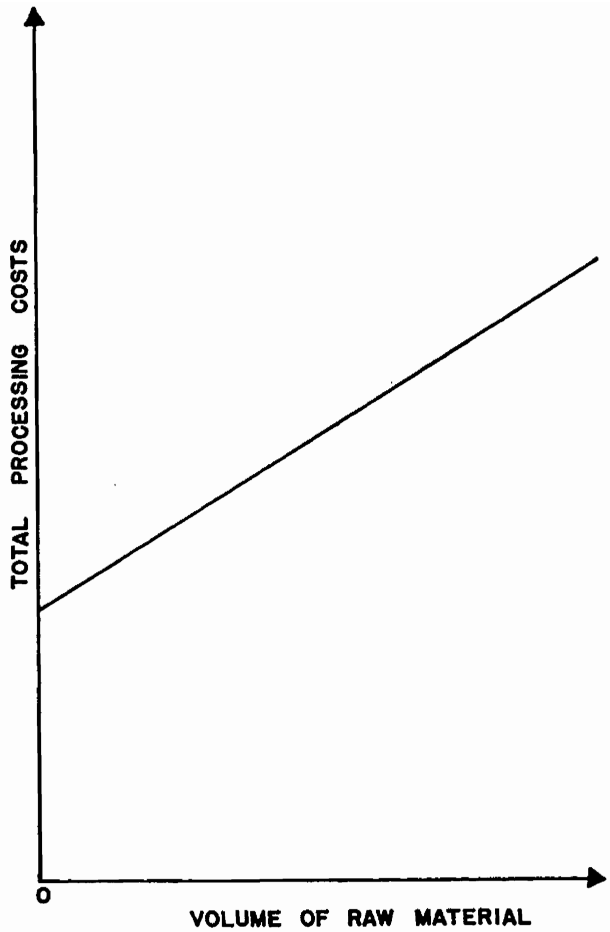

Fig. 2. Total long-run processing cost function for one plant.

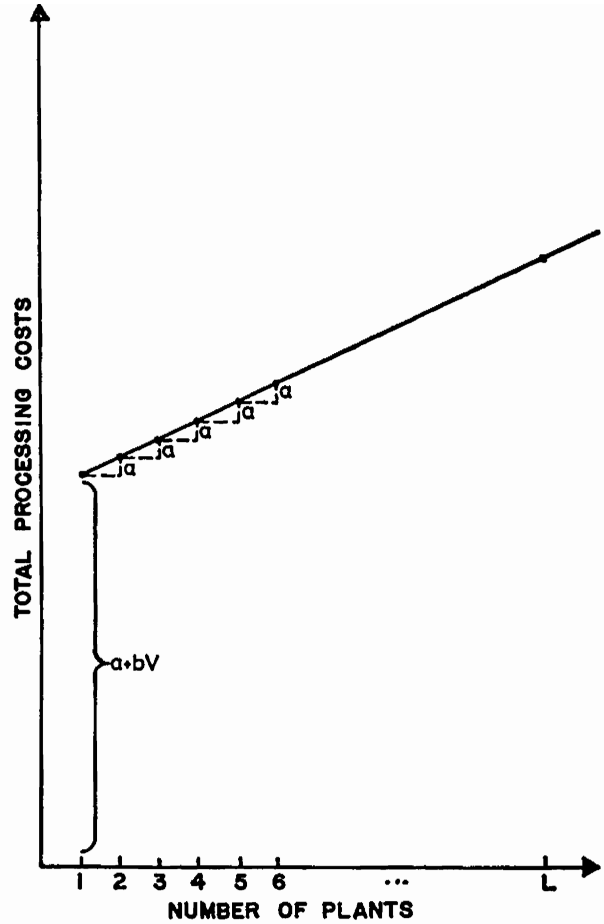

Fig. 3. Total processing cost curve.

The optimum solution is then found by summing the two functions with respect to plant numbers to get

$$TC_{(J,L_K)} = \sum_{j=1}^{J} P_j X_j \mid L_J + \sum_{i=1}^{I} C_m + \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} \mid L_J$$

and selecting the minimum point on the total cost function. The two functions and their aggregate are illustrated in fig. 4.

The minimum point on the total combined cost function designates the optimum number of plants. From the operations performed in finding the total assembly cost function with respect to plant numbers, we can find the optimum location of the optimum number of plants. The supply area of each plant and the volume handled by each plant are also determined in the procedure. We then have the optimum size, number and location of processing plants for the given volume of production and area of assembly.

In the preceding explanation of the model, we made three assumptions used in this study. The first assumption is that economies of scale in plant operations exist, the second is that processing costs are independent of the location of the plant, and the third is that long-run marginal costs are constant.

Research Procedure

The procedure used to determine the optimum number, size and location of egg processing plants is divided into four main steps. Each step will be fully analyzed in a later section.

The first step involves defining the specific spatial area to be considered. This area contains all supply origins and all potential processing plant sites. The choice of spatial area is affected by the area's size and shape and its production pattern and density. The area selected for analysis was a 13-county area in central Iowa, shown in fig. 5.

Origins and potential plant sites within the area considered were defined as *a second step.* The origins were defined by dividing the capacity of the assembly truck into weekly egg production in the county; variations in truck capacities and pickups per week were considered. In defining potential plant sites, only communities with 1,000 population or more were considered.

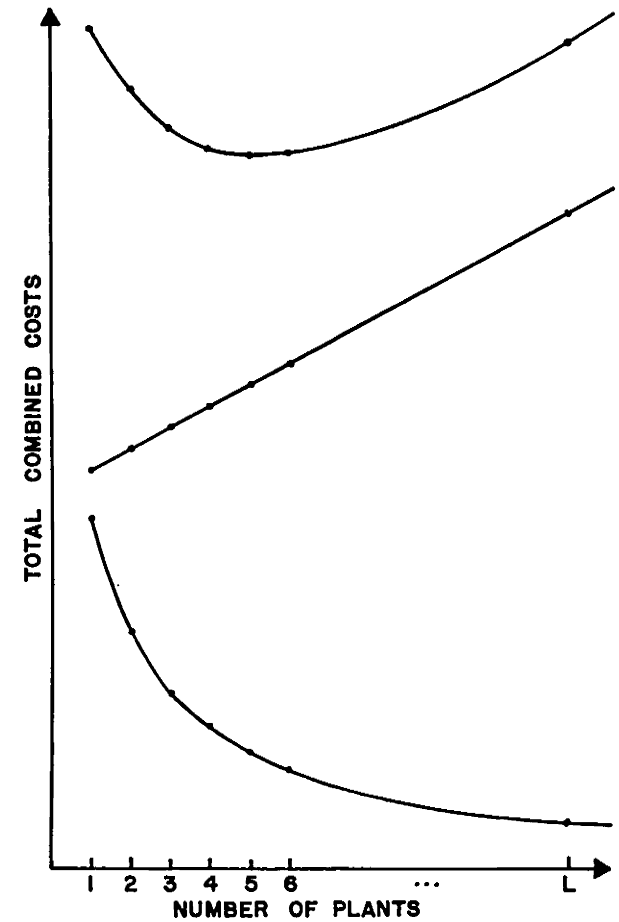

Fig. 4. Combined cost functions. Top curve represents the combined function, center the processing function and bottom the assembly function.

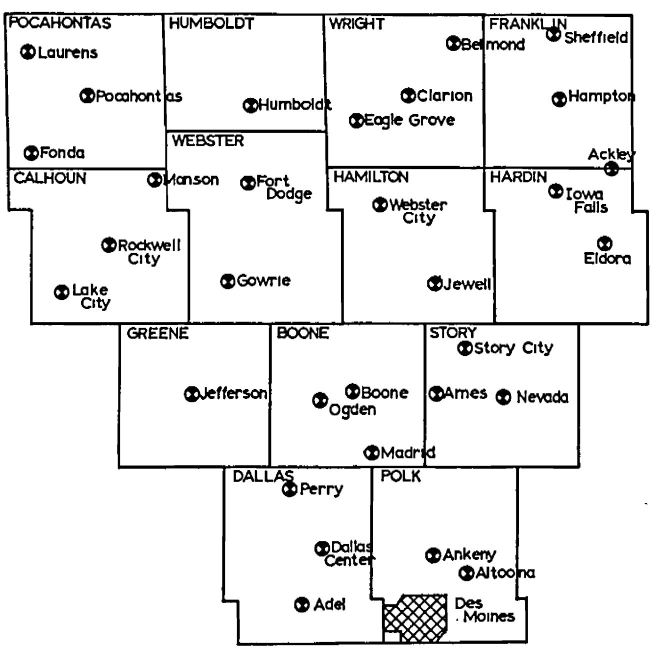

Fig. 5. Area studied with locations of the 32 potential plant sites.

It was expected that these centers would have adequate water, electricity and sewage facilities as well as an adequate labor supply. Assembly cost relationships were determined in the context of these supply origins and potential plant sites.

The third step of the research procedure was to determine the relationship between processing costs and the number, size and location of processing plants. The economic-engineering approach was used to determine total processing costs; the processing cost function was determined by computing the linear regression of volume processed on total processing costs. Variations were allowed in hours operated (single- and double-shifts) and techniques of production (semi-automatic and fully-automatic plant operations).

The fourth and final step in the procedure was to combine the total assembly cost function and the total processing function, both with respect to plant numbers. Thus a total combined cost function with respect to plant numbers was derived. The minimum point of this cost curve indicates the least-cost number of plants. Sizes and locations of these plants can then be deduced.

ESTIMATION OF ASSEMBLY AND PROCESSING COSTS

This section explains in detail the first three steps of the research procedure. Steps one and two are covered in the discussion on assembly costs. Step three is then analyzed under processing costs. The fourth and final step is discussed in the next section, assembly and processing costs under alternative production and marketing organization.

Assembly Costs

To analyze assembly costs, the first step was to define the location of the potential plant sites and the origins of supply. The potential plant sites were defined as all cities or towns of 1,000 or greater population within the 13-county area. Fig. 5 shows the 13-county area and the 32 potential plant sites located in it.

The supply origins were determined by dividing the truck load capacity into the weekly production of each county as given in Census of Agriculture for 1959 (14) to determine the number of origins and, from this, the number of weekly routes within that county. The number of origins was then divided into the total square miles for the county to give the square miles in each route. The routes were then traced into the counties as nearly square as possible. This process was carried out for sizes of truck capacities varying from 50 to 250 cases and for twice-a-week pickup as well as weekly. Table 2 gives the weekly production per county and the number of routes for the five truck sizes analyzed.

The assembly costs were then divided into two main parts. The first was the cost of the routes, which makes up the major portion of the assembly costs. This includes the fixed cost connected with assembly costs and the cost of traveling within each individual route. The second part of the assembly costs was the cost of traveling to and from the established routes and the plant sites (this cost determines the optimum location of the plants).

The assembly cost within the routes involved three main costs: (1) fixed truck costs, (2) mileage costs and (3) labor costs. Fixed truck costs included yearly depreciation, interest, taxes, license fees and issurance. Annual depreciation was figured on a straight-line basis with a life of 5 years. The truck body was assumed to have a salvage value of 10 percent at the end of 5 years. The insulated, temperature controlled truck box was assumed to have a salvage value of 50 percent at the end of 5 years. Costs on the truck body were figured as the minimum list price (including necessary equipment) of the size of the truck needed. The cost of the truck box was based on price quotations from a manufacturer of truck boxes. Interest was computed at 6 percent of the average value over a 5-year period. Insurance costs were quoted on the basis of 25-50-5 liability, comprehensive and $50 deductible collision. Table 3 shows the cost figures for the various sizes of trucks considered. The fixed yearly cost per route was found by dividing the total yearly fixed cost by 5, since it was assumed that each truck could handle 5 routes traveling each route once a week and operating 5 days a week.

The within-route mileage cost was figured by multiplying the number of miles traveled by 8 cents per mile. That amount was the assumed variable cost covering gasoline, oil, servicing and repairs. The number of miles was found by randomly placing the known number of stops on a map of the area, tracing the routes that minimized distance and repeating the process until a consistent mileage figure was determined for every number of stops and square miles of area. After the weekly per-route mileage cost was determined, it was multiplied by 52 to obtain a yearly per-route cost figure.

For the within-route labor cost, a wage rate of $2 per hour was used because this was the wage rate for light truck drivers in the Des Moines area given by the Bureau of Labor Statistics bulletin (15). Time-and-a-half was considered for time over an 8-hour day. The weekly total labor cost per route was found by multiplying this wage rate by the number of hours. The number of hours depended upon: (1) the number of stops made, (2) the cases picked up and (3) the number of route miles driven.

The number of stops made per route depended on the size distribution of the producers and the size of truck used. The existing size distribution of producers was found in the Census of Agriculture (14) and the Iowa Crop and Livestock Reporting Service bulletin (1). From these reports, the percentage distribution of producers in various classes was determined. Table 4 gives the classes of producers, the mean size within

Table 2. Weekly production and number of routes for each county.

County	Weekly production (cases)	Number of routes — Truck capacity (cases) 50	100	150	200	250
Boone	2,435	49	24	16	12	10
Calhoun	1,486	30	15	10	7	6
Dallas	1,760	35	18	12	9	7
Franklin	3,493	70	35	23	17	14
Greene	1,391	28	14	9	7	6
Hamilton	1,624	32	16	11	8	6
Hardin	2,519	50	25	17	13	10
Humboldt	1,471	29	15	10	7	6
Pocahontas	2,316	46	23	15	12	9
Polk	1,175	24	12	8	6	5
Story	1,973	39	20	13	10	8
Webster	1,640	33	16	11	8	7
Wright	2,323	46	23	15	12	9
TOTAL	25,606	511	256	170	128	103

Table 3. Fixed truck costs.

Cost item	Truck size (cases) 50	100	150	200	250
Replacement cost	$3,528.00	$3,840.00	$4,026.00	$5,128.00	$5,192.00
Salvage value	852.80	908.00	933.40	1,063.60	1,095.60
Fixed costs					
Depreciation	535.04	586.40	618.52	812.88	819.70
Interest	131.42	142.44	148.78	185.75	188.63
Tax and license	39.11	55.36	111.10	175.51	245.77
Insurance	153.00	153.00	232.00	232.00	232.00
Total fixed costs	858.57	937.20	1,110.40	1,406.14	1,486.10
FIXED YEARLY COST PER ROUTE	$ 171.71	$ 187.44	$ 222.08	$ 281.23	$ 297.22

Table 4. Classes of producers based on size distributions.

Class	Range of flock sized	Mean flock size	Cases/stop
1	50 – 399	200	2
2	400 – 599	500	5
3	600 – 799	700	7
4	800 – 1,599	1,200	12
5	1,600 – 3,199	2,400	24
6	3,200 or more	3,200	32

Source: Mortenson (8).

that class and the assumed cases per weekly stop from that class.

Appendix A gives the percentage distribution of the various sized producers for the 13 counties and the necessary number of stops per route in each county for the four truck sizes considered with the existing production pattern. For the analysis of costs for production patterns with producers of 1,000, 5,000 or 20,000 layer flocks, the number of stops was determined by dividing the known cases per stop into the truck size. After the number of stops had been determined, it was multiplied by 2.5 minutes, the time per stop as determined by Judge and Baker (4), and then converted to hours (the time spent actually loading cases was not included here).

The time required to pick up the cases of eggs was determined by multiplying the cases per truck load by 0.9 minute, the time required to load a case of eggs as determined by Judge and Baker (4). This figure was then converted into hours.

The number of route miles driven, determined previously for the route mileage costs was multiplied by 2.65 minutes, the time required to drive 1 mile within the route as determined by Judge and Baker (4). Again this figure was converted into hours.

The total weekly route time was found by summing these three figures. The wage rate was then applied and the result multiplied by 52 to get total yearly labor cost per route.

The weekly route time was also used to determine the mileage point at which overtime pay should be applied to the cost of driving between the plant and origin. The difference between the necessary hours per route and the 8-hour limit was found and then multiplied by 17.5 to get the miles to be traveled before the 8-hour limit would be reached. The 17.5 was determined by taking half of the assumed 35 miles per hour traveling speed to get the miles in one direction that the truck could be driven without incurring overtime pay on the return trip.

The three costs for within-route assembly were summed to get the total cost. Appendix B gives the

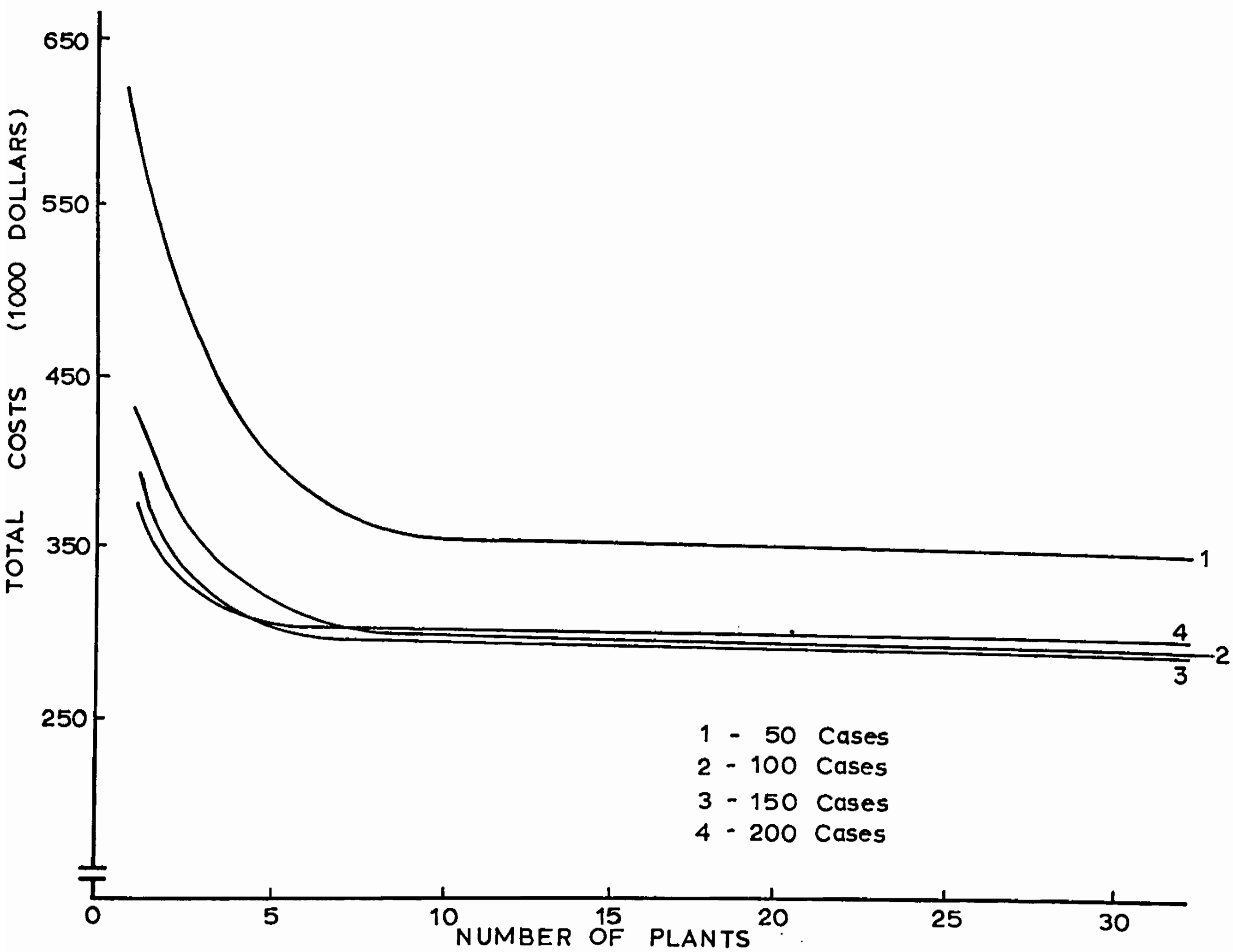

Fig. 6. Assembly cost functions for varying truck sizes and the existing production pattern.

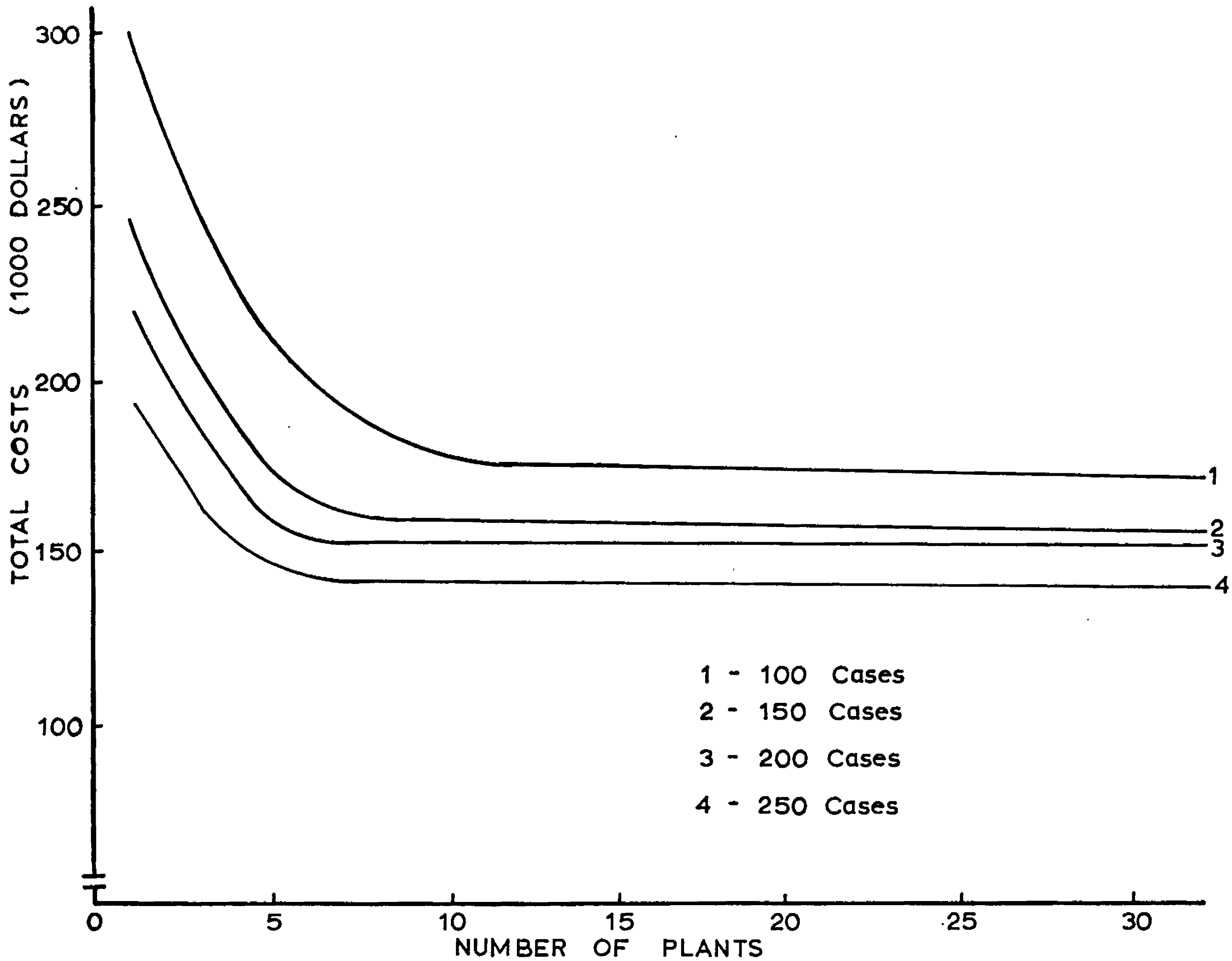

Fig. 7. Assembly cost functions for varying truck sizes and the 1,000-layer flocks (assembly once a week).

breakdown of the three costs and the total costs for the 13 counties for all situations analyzed.

In analyzing the cost of traveling between plants and origins, it was first necessary to determine mileage figures. By using county maps, mileages between every combination of plants and origins were determined for each truck size. These distances were then placed in a transportation matrix. Assuming an average speed of 35 miles per hour, a variable cost of 8 cents per mile and a wage rate of $2 per hour with time-and-a-half for over 8 hours per day, the yearly cost was $7.075 per mile for less than 8 hours with an additional $1.455 per mile for over 8 hours. Both these figures were doubled when applied to the transportation matrix since the matrix contained only one-way mileages between the plants and origins.

A third part of assembly costs was the cost of loading and unloading the trucks at the plant. Since in most cases, the route times approached or exceeded the 8-hour limit, it was assumed that the loading and unloading was handled by employees other than the truck drivers. The only cost involved here was for the labor of plant employees. This labor cost is therefore included in the processing cost analysis where additional employees were needed.

The over-all assembly costs were determined for assembly once each week. For twice-a-week assembly, the 100-case truck was used over the routes established for 200-case trucks for the existing and the 1,000-layer flock production patterns. The fixed truck costs for the twice-a-week assembly were those used for the 100-case truck, doubled because of the decrease in number of routes each truck could handle. For all other costs, the 200-case truck costs were used with the appropriate cost adjustments. The labor cost for assembly within the route was decreased as a result of the decrease in number of cases assembled. The cost of driving between the plants and the origins was doubled because of the increase in the number of times the distance was traveled.

After the assembly costs were determined, a program was written for the IBM 7074 computer to perform the operations as explained in the model discussion. The results given were the minimum assembly

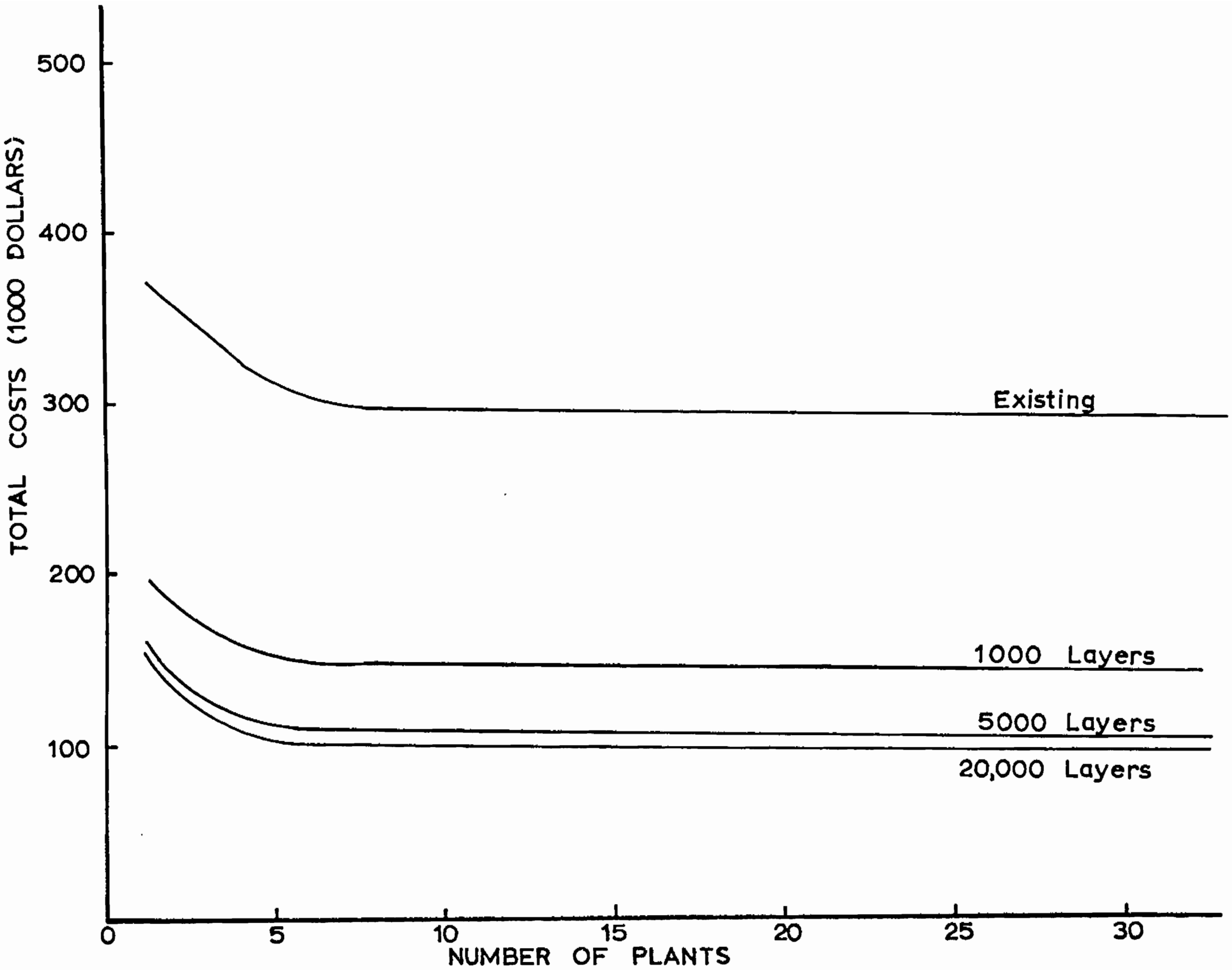

Fig. 8. Assembly cost function for varying production patterns (assembly once a week).

cost for every number of plants and combination of locations. Because of excessive computational costs, not all plant numbers were considered. Appendix C contains the assembly costs for 1, 2, 3 and 32 plants for every situation considered. Total assembly costs dropped sharply by increasing plant numbers from one to three although increasing beyond four seemed to have a lesser impact. This is illustrated in figures 6 through 9 showing minimum assembly costs.

Fig. 6 illustrates the assembly cost functions for the existing production pattern with respect to plant numbers and the four truck sizes. In this situation, the 200-case truck size was the most efficient for one to four plants. For 5 to 32 plants, the 150-case truck size became the most efficient. The change in truck size was due to the effect of overtime pay. The 200-case truck operated over 8 hours per route regardless of the number of plants in operation. But the 150-case truck operated over 8 hours only when a small number of plants was being considered.

Fig. 7 illustrates the assembly cost function with respect to plant numbers for the four truck sizes considered with 1,000-layer flocks. Here, the 250-case truck was the most efficient for all plant numbers.

Fig. 8 illustrates the assembly cost functions with respect to plant numbers for the four production patterns considered. In all cases the minimum cost truck size was used. Under these conditions, assembly costs declined at a decreasing rate as flock sizes increased.

Fig. 9 illustrates the assembly cost function with respect to plant numbers with twice-a-week assembly. Here also the minimum cost truck size was used. This was done for both the existing and the 1,000-layer flock production patterns. With the existing production pattern, assembly costs increased by about 80 percent when going from one to two pickups per week. With the 1,000-layer flock's production, assembly costs increased by about 60 percent throughout.

Processing Costs

This section investigates the in-plant processing costs for grading and packing eggs. The processing costs with both automatic and semi-automatic equipment, average and high quality egg distribution and single- and double-shift operations were considered. For all cases, a sample of plants was constructed by the economic-engineering approach for different volumes of output operating at approximately 90 percent of rated capacity. From this sample, a linear regression was computed to determine a linear total processing cost function with respect to volume that has a positive intercept value. This met the requirements as explained in the model.

By using this procedure, the cost projections represent efficient procedures for processing eggs, but these projections may not represent the minimum cost situation for every rate of output. The cost function may be viewed as the long-run cost curve connecting the points on the short-run cost curves representing operation at approximately 90 percent of capacity. This replaces the actual long-run cost curve which is tangent to every short-run cost curve. Since only the one set of costs for each plant was computed, no cost classification of fixed and variable costs was used.

Using fully automatic equipment was the first situation analyzed. Since this equipment was manufactured to operate only when there is a uniform high-quality grade distribution of eggs, it was assumed that 80 percent of the eggs were cartoned for sale as shell eggs and 20 percent were case-packed. Five model plants were set up with yearly volumes of 33,750, 67,500, 135,000, 270,000 and 540,000 cases for a single-shift operation.

All costs for this situation, with the exception of plant wages, heating and air conditioning, were taken from Peeler and King (10). The costs for plant wages, heating and air conditioning were adjusted to meet conditions existing in Iowa.

In computing costs for plant wages, it was assumed that hourly employees were paid on the basis of 8 hours per day and 250 days per year for a single-shift operation. A wage rate of \$1.50 per hour with an additional cost of 10 percent for fringe benefits was also assumed. The number of hourly employees required for each plant size as determined by Peeler and King is given in table 5. Total plant wages per year were then determined and are given in table 7. Management and of-

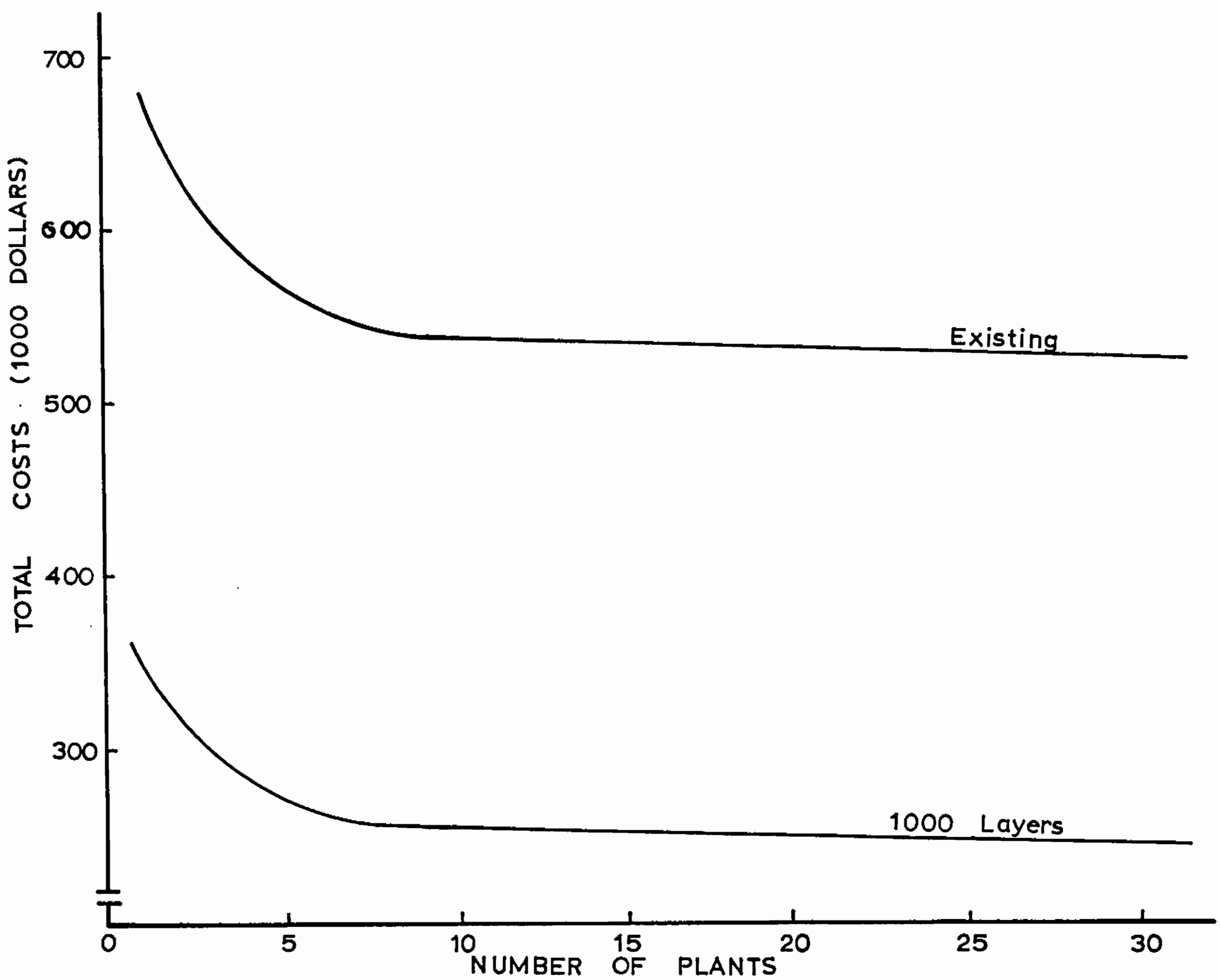

Fig. 9. Assembly cost functions with assembly twice each week.

Table 5. Labor requirements for automatic, single-shift plants.

Operation	Number of men — Plant volume (cases/year) 33,750	67,500	135,000	270,000	540,000
Grading and packing					
Loading machine	1	1	2	4	8
Pregrading	1	1	2	4	8
Candle	1	2	4	8	16
Tend packers	—	2	4	8	16
Pack	1	1	2	4	8
Egg supply and removal	1	1	2	4	8
Loading and unloading trucks	—	1	2	4	8
Clean-up	—	1	1	1	2
TOTAL	5	10	19	37	74

Source: Peeler and King (10).

Table 6. Management and office salaries for automatic, single-shift plants.

Position	Yearly salaries — Plant volume (cases/year) 33,750	67,500	135,000	270,000	540,000
Manager	$6,000	$ 7,200	$ 9,000	$15,000	$25,000
Superintendent ..	—	—	—	7,500	10,000
Foreman	—	—	5,200	5,200	10,400[a]
Secretary	3,000	3,000	3,600	3,600	7,200[a]
Bookkeeper	—	2,000[b]	3,600[b]	6,000	6,000
Payroll clerk	—	—	—	3,600	3,600
Clerk	—	—	—	—	4,800[a]
TOTAL	$9,000	$12,200	$21,400	$40,900	$67,000

[a] Two employees.

[b] Part-time employees.

Source: Peeler and King (10).

fice salaries were also taken from Peeler and King and are given in table 6.

Federal inspection for egg quality was also assumed, and costs were computed on the basis of a base pay of $400 per month plus $35 per month for monthly volumes of 1,000 cases or less and $5 per month for each additional 1,000 cases with a maximum of $550 per month for shell egg inspection. Total yearly costs were then computed and are given in table 7.

Sales costs were made a function of volume and were assumed to be 5 cents per case of eggs. One maintenance man was assumed for all plants except the largest, which was assigned two employees. A yearly salary of $4,500 was assumed.

Building and plant layout data were provided by Hamann and Todd (3) and commercial concerns. List prices on the automatic equipment were used. The basic machine unit operated with a capacity of 20 cases per hour and consisted of an egg washer, flash candler, in-line scales, three manual packing stations and three automatic packaging units. Other equipment included transportation equipment, packing benches and refrigeration equipment. Depreciation, repairs and maintenance, and taxes, interest and insurance were then found for the buildings and listed equipment and for the office, heating and air conditioning equipment as a percentage of the original cost. These cost figures are given in table 7. The carton set-up and dispensing machines, carton closers and turntables were assumed to be rented, and the costs are listed under equipment rental in table 7.

Cost for materials, office supplies and operational supplies were made a function of volume. Material costs were $1 per case. The assembly cases were assumed usable for 33 trips, with two sets required and a cost of $0.285 per case. The filler flats were assumed to make 20 trips and were figured at a cost of $0.018 per flat. The shipping cases were given a cost of $0.18 per case. Cartons and flats were charged at $0.023 and $0.009 each. Office supplies were estimated to be about $0.009 per case. Operational supplies for cleaning, repairs and maintenance in the plant were assumed to be approximately $0.009 per case.

The heating equipment was assumed to operate at 100,000 BTU's per gallon of fuel oil and to operate full time for 6 months of the year. The fuel oil was charged at a rate of $0.15 per gallon. Table 7 gives the yearly heating costs for all plants.

The electricity requirement for lighting was based on 160 watts per 200 square feet of office and grading area and 80 watts per 200 square feet of storage area. The requirement for air conditioning was based on 1 KWH per ton and an operation of 8 hours per day for 4 months. The requirement for the coolers was based on an operation of 8 hours per day. The electricity requirement for the machinery was based on 16.4 KWH per hour of operation per machine.

Water was charged at the rate of $0.05 per hundred gallons with consumption of 60 gallons per hour of operation per machine unit, which includes one candling machine and the attached grading and packaging units.

Table 7 contains the individual and total costs for the five model plants. A linear regression was computed by using the total costs for the five model plants. And the total yearly cost function was determined to be

$$TPC = \$22{,}876.00 + \$1.968V$$

where

TPC = total yearly processing cost, and

V = yearly volume processed in cases.

Costs were then computed for the same plants operating two 8-hour shifts. Costs for buildings, refrigeration and electricity were adjusted to allow for a 50-percent increase in storage capacity. Operational supplies, maintenance salaries, office supplies, inspection costs, sales costs, materials, and repairs and maintenance except for buildings, heating and air conditioning equipment were doubled. A 10-percent increase in the wage rate was assumed for the second shift. Table 8 gives the individual and total costs for the five model plants operation on a double shift.

A linear regression was then computed from these total costs to get a linear total yearly cost function of the form:

$$TPC = \$40{,}930.00 + \$1.822V.$$

The next step in analyzing processing costs was to convert the processing cost function with respect to volume into a function with respect to number of plants. Under the assumptions about the nature of the processing cost function, the procedure was relatively simple. For processing that takes place in one plant, we used the cost function with the total volume to be processed for the designated area. For each additional plant, the total cost increased by the amount of the intercept value of the total processing cost function with respect to volume of output. This addition was made for each increase in plant numbers.

The second situation considered was the use of semiautomatic equipment processing an average grade distribution of eggs. For this study, it was assumed that the plants are cartoning 70 percent of the total volume

Table 7. Total yearly processing costs (automatic equipment, single-shift, 80-20 distribution).

Cost item	Plant volume (cases/year)				
	33,750	67,500	135,000	270,000	540,000
Plant wages	$16,500	$ 33,000	$ 65,700	$122,100	$ 244,200
Management and office salaries	9,000	12,200	21,400	40,900	67,000
Base pay for inspection	4,800	4,800	4,800	4,800	9,600[a]
Variable inspection cost	540	720	1,080	1,740	3,060
Sales	1,687	3,374	6,748	13,496	26,992
Maintenance salaries	4,500	4,500	4,500	4,500	9,000
Depreciation	7,529	13,072	25,517	47,964	92,874
Repairs and maintenance	2,280	3,344	5,890	9,723	17,375
Taxes, interest and insurance	3,773	6,261	11,005	18,691	34,505
Equipment rental	978	1,644	2,976	5,952	11,904
Materials	33,750	67,500	135,000	270,000	540,000
Office supplies	304	608	1,216	2,431	4,862
Operational supplies	304	608	1,216	2,431	4,862
Heat	1,023	1,644	2,712	3,391	7,353
Electricity and water	1,082	2,035	3,839	6,278	11,455
TOTAL	$88,050	$155,310	$293,599	$554,397	$1,085,042

[a] Two inspectors need at this volume.

Table 8. Total yearly processing costs (automatic equipment, double-shift, 80-20 distribution).

Cost item	Plant volume (cases/year)				
	67,500	135,000	270,000	540,000	1,080,000
Plant wages	$ 34,650	$ 69,300	$131,670	$ 256,410	$ 512,820
Management and office salaries	12,200	21,400	40,900	67,000	100,500
Base pay for inspection	9,600	9,600	9,600	9,600	19,200
Variable inspection cost	1,080	1,440	2,160	3,480	6,120
Sales	3,374	6,748	13,496	26,992	53,984
Maintenance salaries	9,000	9,000	9,000	9,000	18,000
Depreciation	7,600	13,240	25,680	48,290	93,467
Taxes, interest and insurance	3,883	6,473	11,258	19,197	35,461
Repairs and maintenance	3,903	5,496	9,870	16,727	30,193
Equipment rental	978	1,644	2,976	5,952	11,904
Materials	67,500	135,000	270,000	540,000	1,080,000
Office supplies	608	1,216	2,431	4,862	9,724
Operational supplies	608	1,216	2,431	4,862	9,724
Heat	1,023	1,645	2,712	4,491	7,353
Electricity and water	1,672	3,149	5,916	9,882	17,642
TOTAL	$157,679	$286,567	$540,100	$1,026,745	$2,006,092

Table 9. Labor requirements for semi-automatic, single-shift plants.

Operation	Number of employees: Plant volume (cases/year) 50,000	100,000	150,000	200,000
Grading and packing				
Load machine	2	3	4	5
Candle	6	12	18	23
Pack	1	2	3	4
Service	2	3	4	5
Loading and unloading trucks	1	2	3	4
Clean-up	1	1	1	1
TOTAL	13	23	33	42

Table 10. Management and office salaries for semi-automatic, single-shift plants.

Position	Plant volume (cases/year) 50,000	100,000	150,000	200,000
Manager	$6,800	$ 8,500	$10,500	$13,000
Superintendent	—	—	—	5,200
Foreman	—	—	5,200	5,200
Secretary	3,000	2,000	3,600	3,600
Bookkeeper	—	3,600[a]	3,600[a]	6,000
Payroll clerk	—	—	—	3,600
TOTAL COST	$9,800	$14,100	$22,900	$36,600

[a] Part-time employees.

and case-packing 30 percent of the total volume. The main source of this analysis information was McRoberts (7). Four plant sizes were considered, processing volumes of 50,000, 100,000, 150,000 and 200,000 cases per year.

The hourly wage rate was assumed to be $1.50 per hour with a 10-percent addition for fringe benefits. The plant was again assumed to operate 8 hours per day and 250 days a year. The number of hourly employees required for each plant size is given in table 9.

From the assumptions concerning wages and hours and the data in tables 9 and 10, total yearly wage costs were determined. These are given in table 11.

The salaries for management and office personnel were made to coincide with those for the automatic plants. Table 10 gives the salaries for the various positions.

Assumptions concerning federal inspection were the same as for the automatic plants. Total yearly costs for inspection appear in table 11. Sales costs and maintenance salaries were also the same and appear in table 11.

For the costs of depreciation, repairs and maintenance, and taxes, interest and insurance, the information is from McRoberts (7). The basic processing unit was a sizing machine supplied by two candlers and operated with a capacity of 350 cases per week. Conveyors then carry the eggs to the packing tables. Other equipment included carton forming and closing machines, packing benches and refrigeration equipment. Costs were again computed on a percentage of the original costs and are given in table 11. The carton set-up and dispensing machines, carton closers and turntables were assumed to be rented, and the rental costs are given in table 11.

Material costs were based on the same assumptions automatic plants were based on. The cost per case was $0.94 for the 70-30 distribution. Office supplies, operational supplies and heat were the same as for the automatic plants.

Electricity costs for light, air conditioning and re-

Table 11. Total yearly processing costs (semi-automatic equipment, single shift, 70-30 distribution).

Cost of item	Plant volume (cases/year) 50,000	100,000	150,000	200,000
Plant wages	$ 42,900	$ 75,900	$108,900	$138,600
Management and office salaries	9,800	15,100	22,900	36,600
Base pay for inspection	4,800	4,800	4,800	4,800
Variable inspection cost	660	900	1,140	1,380
Sales	2,500	5,000	7,500	10,000
Maintenance salaries	4,500	4,500	4,500	4,500
Repairs and maintenace	2,267	3,722	4,671	5,866
Depreciation	3,702	6,705	8,763	11,340
Taxes, interest and insurance	3,617	5,936	7,705	9,346
Equipment rental	510	510	510	1,020
Materials	47,000	94,000	141,000	188,000
Office supplies	450	900	1,350	1,800
Operational supplies	450	900	1,350	1,800
Heat	1,377	2,257	3,032	3,745
Electricity and water	1,539	2,913	5,732	7,345
TOTAL	$126,072	$224,043	$323,853	$426,142

Table 12. Total yearly processing costs (semi-automatic equipment, double shift, 70-30 distribution).

Cost of item	Plant volume (cases/year)			
	100,000	200,000	300,000	400,000
Plant wages	$ 90,090	$159,390	$228,690	$291,060
Management and office salaries	15,100	36,600	41,900	49,500
Base pay for inspection	9,600	9,600	9,600	9,600
Variable inspection cost	1,320	1,800	2,280	2,760
Sales	5,000	10,000	15,000	20,000
Maintenance salaries	9,000	9,000	9,000	9,000
Depreciation	3,771	6,829	8,936	11,564
Repairs and maintenance	3,569	5,916	7,398	9,492
Taxes, interest and insurance	3,671	6,033	7,841	9,522
Equipment rental	510	510	510	1,020
Materials	94,000	188,000	282,000	376,000
Office supplies	900	1,800	2,700	3,600
Operational supplies	900	1,800	2,700	3,600
Heat	1,377	2,257	3,032	3,745
Electricity and water	2,759	5,270	7,545	9,597
TOTAL	$241,567	$444,805	$629,132	$810,060

frigeration were based on the same assumptions as for the automatic plants. These cost figures for the processing machines and candling lights were taken from McRoberts (7).

Table 11 gives the individual and total costs for the semi-automatic model plants.

Again, a linear regression was computed for the total yearly processing cost function. The processing cost function found was of the form:

$$TPC = \$25{,}028.00 + \$2.000V.$$

Costs were then computed for the same plants operating two shifts per day using the previous assumptions. Table 12 gives the individual and total costs for the semi-automatic plants operating on a double shift.

The linear regression resulted in a total yearly processing cost function:

$$TPC = \$59{,}141.00 + \$1.889V.$$

The cost functions were then converted to a total yearly processing cost function with respect to plant numbers.

One small change, that of altering the distribution to 80 percent cartoned and 20 percent case-packed eggs, led to a third situation. Ladd and McRoberts (5) investigated the change in labor requirements resulting from changes in the processing pattern. They found that the indivisibilities in labor requirements were such that the number of laborers did not change for the shift from a 70-30 to an 80-20 distribution.

The only cost changes were an increase in material requirements with a resulting change from $0.94 per case to $1.00 per case.

The resulting total processing cost functions were

$$TPC = \$25{,}028.00 + \$2.060V$$

for the single-shift operation and

$$TPC = \$59{,}141.00 + \$1.949V$$

for the double-shift operation.

Comparing the preceeding total processing functions with the total processing functions on pages 788 and 789 shows that automatic equipment is more efficient than semi-automatic equipment.

ASSEMBLY AND PROCESSING COSTS UNDER ALTERNATIVE PRODUCTION AND MARKETING ORGANIZATION

To determine the least-cost number, size and location of plants, the assembly and processing cost functions were summed to get the total combined cost function. The combined cost function with respect to plant numbers decreased as long as the decrease in assembly costs was greater than the increase in processing costs. The combined cost function was a minimum when the rates of change of the two relationships were equal. The combined cost function increased when the increase in processing costs was greater than the decrease in assembly costs.

The first situation considered was that approximating the existing distribution. In this situation, we considered the semi-automatic plant cartoning 70 percent of eggs handled and case-packing 30 percent. For the assembly costs, we considered the least-cost truck size for the existing production pattern as explained in the section on cost estimation. Table 13 gives the total and average combined costs for the above situation for various plant numbers.

The least-cost solution was one double-shift plant with an average cost of $2.212 per case. The least-cost solution with single-shift operations was one plant with an average cost of $2.297 per case. The least-cost number, size and location of plants for both double- and

Table 13. Total and average combined costs (semi-automatic, existing production pattern, 70-30 distribution).

Number of plants	Total costs		Average costs/case	
	Single shift	Double shift	Single shift	Double shift
1	$3,058,328.44	$2,944,643.61	$2.297	$2.212
2	3,059,745.40	2,980,173.57	2.298	2.238
3	3,065,546.78	3,020,087.95	2.302	2.268
.				
.				
.				
32	$3,750,717.62	$4,694,535.79	$2.817	$3.526

Table 14. Total and average combined costs (automatic, existing production pattern, 80-20 distribution, assembly once each week).

Number of plants	Total costs		Average costs/case	
	Single shift	Double shift	Single shift	Double shift
1	$3,013,568.06	$2,837,221.30	$2.263	$2.131
2	3,012,833.02	2,854,540.26	2.263	2.144
3	3,016,482.40	2,876,243.64	2.265	2.160
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.				
32	$3,639,245.24	$4,022,572.49	$2.733	$3.021

single-shift operations was one plant, located at Webster City, with an annual volume of 1,331,512 cases. For 1 to 4 plants, the double-shift was more efficient. For 5 or more plants, the single-shift plants were more efficient.

The second situation analyzed involved a grade distribution of eggs that allowed the use of automatic equipment.

It has already been shown in the section on cost estimation that, when the grade distribution is 80 percent cartoned and 20 percent case-packed eggs, automatic equipment was more efficient than semi-automatic equipment. We again considered the existing production patterns and the least-cost truck size. Table 14 gives the total and average combined costs for varying numbers of plants with the existing production pattern.

The least-cost solution for this situation was one plant operating on a double-shift with an average cost of $2.131 per case. With plants operating on a single shift, the least-cost was achieved with two plants with an average cost of $2.263 per case. The least-cost size and location of plants was the same as the previous situation, since this was determined by the transportation matrix, which was the safe for both situations. With the automatic equipment processing the 80-20 distribution, there were cost reductions of 3.6 percent for the double shift and 1.5 percent for the single shift compared with the least-cost solution for the semi-automatic equipment processing the 70-30 distribution. For 1 to 11 plants, the double-shift operation was more efficient. For 12 or more plants, the single-shift operation was more efficient.

Table 15. Total and average combined costs (1,000-layer flocks, 5,000-layer flocks and 20,000-layer flocks, assembly once each week).

Number of plants	Total costs		Average costs/case	
	Single shift	Double shift	Single shift	Double shift
	1,000-layer flocks			
1	$2,834,185.31	$2,657,838.55	$2.129	$1.996
2	2,838,731.19	2,680,438.43	2.132	2.013
3	2,848,688.91	2,708,450.15	2.139	2.034
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32	$3,488,982.78	$3,872,310.03	$2.620	$2.908
	5,000-layer flocks			
1	$2,796,995.37	$2,620,648.61	$2.101	$1.968
2	2,803,269.79	2,644,977.03	2.105	1.986
3	2,814,839.65	2,674,600.89	2.114	2.009
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32	$3,457,513.90	$3,840,841.15	$2.597	$2.885
	20,000-layer flocks			
1	$2,793,315.36	$2,616,968.60	$2.098	$1.965
2	2,796,607.76	2,638,315.00	2.100	1.981
3	2,803,536.71	2,663,297.95	2.106	2.000
.				
.				
.				
32	$3,442,036.71	$3,825,363.96	$2.585	$2.873

Third, the effect of the production pattern on the optimum solution was analyzed. The automatic processing technique with the 80-20 distribution was used. Production patterns of the existing pattern, 1,000-layer flocks, 5,000-layer flocks and 20,000-layer flocks were considered.

Table 15 gives the total and average combined costs for the 1,000-layer flocks, 5,000-layer flocks and 20,000-layer flocks.

The situation with the existing production pattern has previously been analyzed. When the production pattern was changed to all flocks of 1,000 layers, the least-cost solution was one double-shift plant located at Webster City, with an average cost of $1.996 per case. This was a decrease of 6.3 percent over the existing production pattern. With single-shift operations, the least-cost situation was one plant located at Webster City, with an average cost of $2.129 per case. This was a decrease of 5.9 percent over the least-cost single-shift operation for the existing distribution.

For the 5,000-layer flocks production pattern, the

Table 16. Total and average costs with assembly twice each week.

Number of plants	Total costs Single shift	Double shift	Average costs/case Single shift	Double shift
	Existing pattern			
1	$3,319,204.40	$3,142,857.64	$2.493	$2.360
2	3,294,858.32	3,136,565.56	2.475	2.356
3	3,279,345.10	3,139,106.34	2.463	2.358
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32	$3,872,437.36	$4,255,764.61	$2.908	$3.196
	1,000-layer flocks			
1	$2,979,338.32	$2,802,991.56	$2.238	$2.105
2	2,965,287.09	2,806,994.33	2.227	2.108
3	2,960,429.75	2,820,190.99	2.223	2.118
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.				
.				
32	$3,576,270.67	$3,959,597.92	$2.686	$2.974

least-cost solution was again a single plant for both the single- and double-shift operations. The average cost was $1.968 per case for the double shift, a decline of 7.6 percent from the existing production pattern and 1.4 percent from the 1,000-layer flocks production pattern. The average cost was $2.101 per case for the single-shift operation. This was a decline of 7.2 percent from the existing and 1.3 percent from the 1,000-layer flock production patterns.

For the 20,000-layer flocks production pattern, the least-cost solution was one double-shift plant with an average cost of $1.965 per case. This was a decrease of 7.8 percent, 1.6 percent and 0.2 percent from the existing, 1,000-layer flocks and 5,000-layer flocks production patterns, respectively. With single-shift plants, the least cost was achieved with a single plant with an average cost of $2.098 per case. This accounted for percentage decreases of 7.3, 1.5 and 0.1.

The final least-cost solution considered was that involving assembly of eggs twice each week. Both the existing and the 1,000-layer flocks production patterns were considered with the automatic processing equipment. Table 16 gives the total and average combined costs for both the existing and the 1,000-layer flock's production patterns with two pickups per week. This table may be compared with tables 14 and 15 where pickup was once each week.

When the eggs were assembled twice each week instead of once each week, the least-cost solution with the existing production pattern changed from one double-shift plant to two double-shift plants. The average combined cost increased from $2.131 to $2.356 per case. This was an increase of $0.225 per case or 10.6 percent. The least-cost locations and sizes of the double-shift plants were Clarion and Boone, processing annual volumes of 676,271 and 655,241 cases, respectively. The least-cost solution with single-shift operations was three plants with an average combined cost of $2.463 per case. This was an increase of $0.107 per case or 4.5 percent over the least-cost double-shift solution. This was also an increase of $0.20 per case or 8.8 percent over the least-cost single-shift solution assembling eggs once each week. The least-cost locations and sizes of plants operating on a single shift were Humboldt, Iowa Falls and Boone, processing annual volumes of 343,304, 478,504 and 509,704 cases, respectively.

The least-cost solution for the production pattern of 1,000-layer flocks and assembly twice each week was one double-shift plant with an average combined cost of $2.105 per case. This was an increase of $0.109 per case or 5.5 percent over the least-cost solution with assembly once each week. The least-cost solution with single-shift plants is three plants with the same locations and sizes as the previous solution. The average combined cost was $2.223 per case. This was an increase of $0.118 or 5.6 percent over the least-cost double-shift solution and an increase of $0.093 or 4.4 percent over the least-cost single-shift solution that assembles eggs once each week.

Another factor considered was the effect of production density on assembly costs. To examine this, the total volume of production was held constant while varying the size of area within which the eggs were to be assembled. Flock size was held constant at 5,000 layers, and assembly was once each week. The truck capacity considered was that of the least-cost size of 250 cases.

Since the least-cost solution was one plant, the procedure used was to take the least-cost location of Webster City and to contract the area size around it. The areas considered were 1) the 13 counties, 2) a 25-mile radius and 3) a 10-mile radius around Webster City.

The density figures were 3.4 cases produced per week per square mile for the 13-county area, 13 cases for the 25-mile radius area and 81.5 cases for the 10-mile radius.

Under the given assumptions, the total yearly assembly cost for the 13-county area was $153,703.75. When the area was reduced to a 25-mile radius and the density of production increased to 13 weekly cases per square mile, the total yearly assembly cost fell to $109,879.22. This was a decrease of $0.033 per case. Reducing the area to the 10-mile radius area with a production density of 81.5 weekly cases per square mile decreased the total yearly assembly cost to $87,192.76. This was a decrease of $0.050 per case from the assembly cost with a production density of 3.4 weekly cases per square mile for the 13-county area.

CONCLUSIONS

The main objective of this study was to determine the effects of various factors on the least-cost number, size and location of processing plants. The second main objective was to determine the cost differences, in assembling and processing eggs, resulting from these factors.

The first factor considered was truck size. The results showed that the main effect of the truck size for fixed plant numbers was in the level of the assembly costs. For a small number of plants, an increase in plant numbers sharply reduced assembly costs regardless of truck size. For plant numbers greater than five, there was no appreciable change in assembly costs. Under the existing production pattern, the least-cost solution would be with the 200-case truck. If the number of plants increased, however, to six or more plants, the truck with a capacity of 150 cases became the most economical.

For production patterns of flock sizes of 1,000 layers or more, the most economical truck size was the largest considered for any number of plants. This was the 250-case capacity truck. Truck size also played a minor role in determining the least-cost number of plants. In general, the larger the truck capacity, the fewer the number of plants.

Production pattern had a substantial effect on assembly costs, with the greatest cost reduction taking place when moving from the existing production pattern to the production pattern composed of all flocks of 1,000 layers. The cost reductions were increasingly less significant when the production pattern was changed to larger and larger flock sizes. The production pattern also influenced the number, size and location of processing plants. As the flock sizes increased, the number of plants decreased, and, therefore, the sizes of plants increased. The location of plants was influenced more by the density of production than by the production pattern.

It is obvious that the more frequently the assembly route is traveled in a week, the higher the assembly cost will be. Frequency of assembly was considered, however, because of its importance in quality-control programs. Costs did not double when the number of trips per week doubled. The amount of increase in costs depended on the production pattern. The larger the flock size, the smaller the cost increase. Frequency of assembly also affected the number and size of plants. The more frequent the assembly, the larger the number of plants, and the smaller the size of plants.

The production techniques considered were the semi-automatic and automatic plants. When solving for the least-cost solution, the automatic plants were always more efficient than the semi-automatic. Technique of production influenced the number of plants to some extent. In each case the solutions for semi-automatic plants were a larger number of smaller sized plants for the automatic plants.

The double-shift operation reduced costs when large plants were considered. Also, a double shift decreased the number of plants and increased plant size in comparison with the single-shift plants.

The higher quality grade distribution of eggs within the plant increased processing costs because of the increased packaging costs for the higher quality eggs. In terms of number and size of plants, egg quality had little effect. There was some tendency for larger and fewer plants to relate to higher quality eggs because of the increased share that processing costs made up of the total combined costs.

In general, the results of the study suggest the need for fewer and larger processing plants with the use of automated equipment. Results suggest the importance of multiple shifts in plant operations.

In assembly, the study shows a need for larger truck sizes and larger supply areas. It also shows the cost reduction resulting from increased producer sizes. This, however, must also be compared with production cost differences.

Since the least-cost solution cannot be reached in one quick change, this study also points to the possible steps to be taken in reaching the least-cost solution.

In general, the least-cost solution can be considered as a static equilibrium situation dependent upon the technology available. In this sense, it is useful in that it can serve as a guide to the future development of the industry. To industry leaders, it shows where savings can be had for the industry as a whole. To the individual firms within the area, it shows the path of adjustment needed to remain competitive if the industry as a whole moves toward this optimum situation. In an over-all appraisal of the industry, the least-cost solution can be used as a basis for comparison to judge the degree of efficiency of the existing structure of the industry.

A serious shortcoming of the least-cost solution is its failure to consider the effect of competition among firms on the solution. The solution might have differed if firms were allowed to compete for the position(s) given in the least-cost solution. In fact, the number of firms would probably increase because of increased competition in raw material procurement. Competition within the origins would also tend to increase costs of assembly and possibly make some origins unattainable to some potential plants. In this regard, the results are useful if we ignore the competition for supply and assume that the resulting supply is assigned to the firms. On this basis, we are again able to make comparisons between existing costs and possible costs from the solutions obtained.

Another shortcoming is the effect of the size of area considered on the least-cost solution. If the least-cost solution had contained a large number of plants, this would not be too important. Since the solution was one of a few plants, a change in the size of the area can be very important. If the area were changed from the 13 counties to the entire state of Iowa, it is possible (although unlikely) that no plant site considered in this study would be in the least-cost solution. Since the least-cost solution was a single plant in most cases, the results can be considered in terms of the effects on a single firm. Reducing the area while holding everything else constant would analyze the effects of concentrating egg production for processing in a single plant. This could be done up to the point where all economic activity takes place in a single location.

The least-cost solution gives the number of plants, sizes of plants, locations of plants and the areas of supply for the plants. The number of plants in the least-cost solution is considerably less than the existing number of plants. Therefore, the study has pointed to a source of inefficiency—that is, too many plants to handle the existing supply of eggs. This means that plants would have to be abandoned before the least-cost solution could be reached. This is a slow process because plants are gradually depreciated and are no longer economical to operate. As long as the owners are making enough margin to cover variable costs, a plant will remain in existence. The adoption of the lower-cost production techniques and plant sizes by innovators can hasten the removal of the marginal firms. If firms can operate at lower cost, they may be able to maintain their margins while paying higher prices for their eggs. This will make operations unprofitable for less efficient competitors. It will also allow plants to secure the additional volume of raw material needed for their larger size. Unless competition drives the cost of purchasing the egg supply up enough to change the least-cost solution, the number of plants will eventually reach that of the least-cost solution. This considers only the profit for competitors. We must also consider the return on resources in the industry as a whole compared with alternative enterprises. And we must look at returns to producers. This definitely suggests possibilities for further research.

Plant size is directly related to plant number and the distribution of the raw material supply. Plant sizes as given in the least-cost solution can serve as guides to future plant construction or present plant expansion. Study results show the approximate range of sizes that will give maximum efficiency. The exact size is dependent upon the available supply of raw materials. The results indicate that existing plants must either adjust to this size of plant or face stiff cost competition from those who do.

The location of plants in the least-cost solution is probably of least importance. Plant location is most seriously affected by changes in the area of supply considered. It is also greatly affected by the present plant locations and competitors' locations. The relaxation of the assumption of equal costs regardless of location would also influence the final plant location. If two innovators were to adjust to the optimum solution, they would not knowingly build in the same location or adjacent locations and compete with each other.

The costs determined in the final solution may not be actually attainable. Assumptions regarding wage rates, management salaries, material costs and other operation costs may not be those actually used by the firms when the adjustments toward the least-cost solution have been made. The adjustments can also influence the costs of assembly and the prices paid to the producers.

Another important consideration for analysis is the model itself. In terms of the general results and implications for future planning in the industry, the model can be a very useful tool. Some of its shortcomings, however, can be seen in its assumptions. The assumption regarding the linear total cost function probably comes close to what is actually in existence when we consider only one production technique as we did. But if we consider all techniques simultaneously, this assumption would probably not be very realistic, nor would the assumed positive intercept value.

The assumption that the value of the positive intercept of the total cost function in some way represents the additional cost of another plant is a serious shortcoming. The actual value in the long run would be much less, since a small room with a single manual candling operation could represent the additional plant.

The assumption that processing costs are independent of location is also unrealistic, although not too serious. It would definitely influence the final locations of the least-cost number of plants.

The previous discussion suggests the need for more research. Additional research is needed, not only on the model, but also on the cost figures constituting the model's empirical content. The results of a complete revision of the underlying model and empirical data in terms of the least-cost solution would almost certainly show a decrease in the cost of assembling and processing eggs under the new least-cost solution. Thus, the solution is not a true optimum, but a suboptimum based on dated technology and empirical relationships. The major importance of the solution is in the general implications with regard to the future direction of the industry. However, long before the industry achieves the structure indicated here, basic changes will have occurred and altered the efficient organization of the industry.

APPENDIX A

The percentage distribution of producer sizes for each county in the given area was found and classified according to the classification given in table 4. The number of stops per route was then determined by multiplying the percentage of total flocks in each size class by the assumed cases per stop for that class as given in table 4. The results were then summed for each class and divided into the truck capacity to get the number of stops per route. Table A-1 gives the percentage distribution of producer sizes and the number of stops in each county for 50, 100, 150 and 200 case trucks for the existing production pattern.

Table A-1. Percentage distribution of producer sizes and number of stops per route for each county.

County	Percentage in class — Class 1	2	3	4	5	6	Number of stops — Truck capacity (cases) 50	100	150	200
Boone	79.5	12.0	3.0	3.0	2.0	0.5	15	29	44	58
Calhoun	86.0	10.0	2.0	2.0	0.0	0.0	19	38	57	76
Dallas	83.0	10.0	2.0	3.0	1.0	1.0	16	31	47	62
Franklin	66.0	22.0	7.0	5.0	0.0	0.0	14	28	42	56
Greene	88.0	8.0	2.0	1.0	1.0	0.0	19	38	57	76
Hamilton	84.5	10.0	3.0	2.0	0.5	0.0	18	36	54	72
Hardin	76.0	16.0	4.0	4.0	0.0	0.0	16	32	58	64
Humboldt	78.5	13.0	4.0	4.0	0.5	0.0	16	32	58	64
Pocahontas	81.0	13.0	3.0	3.0	0.0	0.0	18	35	53	70
Polk	82.0	10.0	2.0	4.0	1.0	1.0	15	30	45	60
Story	79.0	14.0	3.0	3.0	0.5	0.5	16	32	58	64
Webster	83.0	12.0	3.0	2.0	0.0	0.0	19	37	56	74
Wright	74.0	16.0	5.0	4.0	1.0	0.0	15	30	45	60

APPENDIX B

The within-route costs of assembling eggs was the major component of the assembly costs. They were computed separately for each of the 13 counties by using the average production pattern and density of each county. The following table gives the total within-route cost for each county and the three major parts of this total cost. The three cost components were (1) the fixed truck cost, (2) the variable truck cost and (3) the labor cost. Cost figures are given for existing, 1,000-layer and 5,000-layer production patterns. In this case, each route had only one producer; thus, only a single stop was required, and all mileage was between the single producer and the plant. This made costs uniform for every route and every county. For this case, the yearly fixed truck cost was $281.23. The yearly variable truck cost was $41.60. The yearly labor cost was $345.80. The total yearly cost per route for this situation was $668.63.

In table B-1 each of the situations studied is considered. The first note is the capacity size of the assembly truck, the second is the production pattern considered and the third is the frequency of assembly.

Table B-1. Yearly costs for assembly within the routes for each county and the various situations analyzed.

County	Fixed truck cost	Variable truck cost	Labor cost	Total cost
	50 cases—existing—weekly			
Boone	$171.71	$ 120.64	$ 274.04	$ 566.39
Calhoun	171.71	185.12	364.52	721.35
Dallas	171.71	162.24	324.48	658.43

Table B-1. (continued)

County	Fixed truck cost	Variable truck cost	Labor cost	Total cost
Franklin	171.71	89.44	237.64	498.79
Greene	171.71	199.68	380.64	752.03
Hamilton	171.71	174.72	348.92	695.35
Hardin	171.71	116.48	276.12	564.31
Humboldt	171.71	143.52	305.76	620.99
Pocahontas	171.71	124.80	291.72	588.23
Polk	171.71	216.32	381.68	769.71
Story	171.71	139.36	301.08	612.15
Webster	171.71	216.32	397.28	785.31
Wright	171.71	124.80	280.80	577.31
	100 cases—existing—weekly			
Boone	$187.42	$ 241.28	$ 548.08	$ 976.78
Calhoun	187.42	370.24	729.04	1,286.70
Dallas	187.42	324.48	648.96	1,160.86
Franklin	187.42	178.88	475.28	841.58
Greene	187.42	399.36	761.28	1,348.06
Hamilton	187.42	349.44	697.84	1,234.70
Hardin	187.42	232.96	552.24	972.62
Humboldt	187.42	287.04	611.52	1,085.98
Pocahontas	187.42	249.60	583.44	1,020.46
Polk	187.42	432.64	763.36	1,383.42
Story	187.42	278.72	602.16	1,068.30
Webster	187.42	432.64	794.56	1,414.62
Wright	187.42	249.60	561.60	998.62
	150 cases—existing—weekly			
Boone	$222.08	$ 361.92	$ 822.12	$1,406.12
Calhoun	222.08	555.36	1,224.60	2,002.04
Dallas	222.08	486.72	1,044.16	1,752.96
Franklin	222.08	268.32	712.92	1,203.32
Greene	222.08	599.04	1,296.88	2,118.00

Table B-1. (continued)

County	Fixed truck cost	Variable truck cost	Labor cost	Total cost
Hamilton	222.08	524.16	1,153.88	1,900.12
Hardin	222.08	349.44	828.36	1,399.88
Humboldt	222.08	430.56	959.92	1,612.56
Pocahontas	222.08	374.40	904.28	1,500.76
Polk	222.08	648.96	1,301.56	2,172.60
Story	222.08	418.08	938.60	1,578.76
Webster	222.08	648.96	1,371.76	2,242.80
Wright	222.08	374.40	847.60	1,444.08
200 cases—existing—weekly				
Boone	$281.23	$ 482.56	$1,228.24	$1,992.03
Calhoun	281.23	740.48	1,771.12	2,792.83
Dallas	281.23	648.96	1,530.88	2,461.07
Franklin	281.23	357.76	1,009.84	1,648.83
Greene	281.23	798.72	1,867.84	2,947.79
Hamilton	281.23	698.88	1,677.52	2,657.63
Hardin	281.23	465.92	1,240.72	1,987.87
Humboldt	281.23	574.08	1,418.56	2,273.87
Pocahontas	281.23	499.20	1,334.32	2,114.75
Polk	281.23	865.28	1,874.08	3,020.59
Story	281.23	557.44	1,390.48	2,229.15
Webster	281.23	865.28	1,967.68	3,114.19
Wright	281.23	499.20	1,268.80	2,049.23
100 cases—1,000 layers—weekly				
Boone	$187.42	$ 104.00	$ 313.98	$ 605.40
Calhoun	187.42	133.12	345.70	666.24
Dallas	187.42	120.64	333.32	641.38
Franklin	187.42	87.36	294.32	569.10
Greene	187.42	133.12	345.70	666.24
Hamilton	187.42	124.80	337.69	649.91
Hardin	187.42	99.84	310.34	597.60
Humboldt	187.42	112.32	322.82	622.56
Pocahontas	187.42	104.00	313.98	605.40
Polk	187.42	145.60	359.53	692.55
Story	187.42	108.16	318.66	614.24
Webster	187.42	145.60	359.53	692.55
Wright	187.42	104.00	313.98	605.40
150 cases—1,000 layers—weekly				
Boone	$222.08	$ 145.60	$ 460.72	$ 828.40
Calhoun	222.08	191.36	510.64	924.08
Dallas	222.08	183.04	501.28	906.40
Franklin	222.08	124.80	437.84	784.72
Greene	222.08	195.52	515.84	933.44
Hamilton	222.08	178.88	497.12	898.08
Hardin	222.08	145.60	460.72	828.40
Humboldt	222.08	162.24	478.40	862.72
Pocahontas	222.08	153.92	469.04	845.04
Polk	222.08	212.16	533.52	967.76
Story	222.08	162.24	478.40	862.72
Webster	222.08	208.00	529.36	959.44
Wright	222.08	153.92	469.04	845.04
200 cases—1,000 layers—weekly				
Boone	$281.23	$ 191.36	$ 609.44	$1,082.03
Calhoun	281.23	274.56	702.00	1,257.79
Dallas	281.23	262.08	687.44	1,230.75
Franklin	281.23	153.92	567.84	1,002.99
Greene	281.23	278.72	706.16	1,266.11

Table B-1. (continued)

County	Fixed truck cost	Variable truck cost	Labor cost	Total cost
Hamilton	281.23	257.92	683.28	1,222.43
Hardin	281.23	191.36	609.44	1,082.03
Humboldt	281.23	224.64	646.88	1,152.75
Pocahontas	281.23	208.00	628.16	1,117.39
Polk	281.23	299.52	729.04	1,309.79
Story	281.23	224.64	646.88	1,152.75
Webster	281.23	291.20	719.68	1,292.11
Wright	281.23	208.00	628.16	1,117.39
250 cases—1,000 layers—weekly				
Boone	$297.22	$ 199.68	$ 718.64	$1,215.54
Calhoun	297.22	299.52	828.88	1,425.62
Dallas	297.22	282.88	810.16	1,390.26
Franklin	297.22	145.60	659.36	1,102.18
Greene	297.22	299.52	828.88	1,425.62
Hamilton	297.22	303.68	833.04	1,433.94
Hardin	297.22	199.68	718.64	1,215.54
Humboldt	297.22	241.28	764.40	1,302.90
Pocahontas	297.22	212.16	732.16	1,241.54
Polk	297.22	332.80	865.28	1,495.30
Story	297.22	232.96	755.04	1,285.22
Webster	297.22	316.16	847.60	1,460.98
Wright	297.22	212.16	732.16	1,241.54
250 cases—5,000 layers—weekly				
Boone	$297.22	$ 116.48	$ 540.28	$ 953.98
Calhoun	297.22	158.08	586.14	1,041.44
Dallas	297.22	153.92	581.57	1,032.71
Franklin	297.22	83.20	503.46	883.88
Greene	297.22	158.08	586.14	1,041.44
Hamilton	297.22	158.08	586.14	1,041.44
Hardin	297.22	116.48	540.28	953.98
Humboldt	297.22	141.44	567.84	1,006.50
Pocahontas	297.22	133.12	558.58	988.92
Polk	297.22	166.40	595.40	1,059.02
Story	297.22	141.44	567.84	1,006.50
Webster	297.22	162.24	590.82	1,050.28
Wright	297.22	133.12	558.58	988.92
200 cases—existing—twice weekly				
Boone	$374.84	$ 965.12	$2,144.48	$3,484.44
Calhoun	374.84	1,480.96	3,230.24	5,086.04
Dallas	374.84	1,297.92	2,749.76	4,422.52
Franklin	374.84	715.52	1,707.68	2,798.04
Greene	374.84	1,597.44	3,423.68	5,395.96
Hamilton	374.84	1,397.76	3,043.04	4,815.64
Hardin	374.84	931.84	2,169.44	3,476.12
Humboldt	374.84	1,148.16	2,525.12	4,048.12
Pocahontas	374.84	998.40	2,356.96	3,730.20
Polk	374.84	1,730.56	3,436.16	5,541.56
Story	374.84	1,114.88	2,468.96	3,958.68
Webster	374.84	1,730.56	3,623.36	5,728.76
Wright	374.84	998.40	2,225.60	3,598.84
200 cases—1,000 layers—twice weekly				
Boone	$374.84	$ 382.72	$ 906.88	$1,664.44
Calhoun	374.84	549.12	1,092.00	2,015.96
Dallas	374.84	524.16	1,062.88	1,961.88
Franklin	374.84	307.84	823.68	1,506.36
Green	374.84	557.44	1,100.32	2,032.60
Hamilton	374.84	515.84	1,054.56	1,945.24

Table B-1. (continued)

County	Fixed truck cost	Variable truck cost	Labor cost	Total cost
Hardin	374.84	382.72	906.88	1,664.44
Humboldt	374.84	449.28	981.76	1,805.88
Pocahontas	374.84	416.00	944.32	1,735.16
Polk	374.84	599.04	1,146.08	2,119.96
Story	374.84	449.28	981.76	1,805.88
Webster	374.84	582.40	1,127.36	2,084.60
Wright	374.84	416.00	944.32	1,735.16

APPENDIX C

Table C-1 contains the minimized total assembly cost for 1, 2, 3 and 32 plants. It also gives the names of the potential plant sites found optimum under the given conditions for each of the plant numbers. The information is given for each situation considered. The first note is the assembly truck capacity, the second is the production pattern and the third is the frequency of assembly.

Table C-1. Minimized total assembly costs for various situations and plant numbers.

Number of plants	Optimum locations	Total assembly cost
	50 cases—existing—weekly	
1...........	Webster City	$614,774.04
2...........	Clarion—Boone	537,587.50
3...........	Humboldt—Iowa Falls—Madrid	472,573.67
32...........	All	349,921.08
	100 cases—existing—weekly	
1...........	Webster City	$430,690.81
2...........	Eagle Grove—Boone	386,725.27
3...........	Manson—Iowa Falls—Boone	352,160.66
32...........	All	292,278.06
	150 cases—existing—weekly	
1...........	Webster City	$388,528.96
2...........	Clarion—Boone	354,039.31
3...........	Manson—Iowa Falls—Madrid	330,569.66
32...........	All	286,797.62
	200 cases—existing—weekly	
1...........	Webster City	$370,276.44
2...........	Clarion—Boone	346,665.40
3...........	Humboldt—Iowa Falls—Boone	327,438.78
32...........	All	297,413.18

Table C-1. (continued)

Number of plants	Optimum locations	Total assembly cost
	100 cases—1,000 layers—weekly	
1...........	Webster City	$302,167.15
2...........	Clarion—Boone	262,238.76
3...........	Manson—Iowa Falls—Boone	231,106.27
32...........	All	172,556.06
	150 cases—1,000 layers—weekly	
1...........	Webster City	$241,832.74
2...........	Clarion—Boone	212,031.10
3...........	Hampton—Manson—Madrid	192,383.08
32...........	All	155,140.28
	200 cases—1,000 layers—weekly	
1...........	Webster City	$215,395.79
2...........	Clarion—Boone	193,894.50
3...........	Humboldt—Iowa Falls—Boone	176,611.76
32...........	All	151,239.25
	250 cases—1,000 layers—weekly	
1...........	Webster City	$190,893.69
2...........	Eagle Grove—Boone	172,563.57
3...........	Manson—Iowa Falls—Madrid	159,645.29
32...........	All	136,535.16
	250 cases—5,000 layers—weekly	
1...........	Webster City	$153,703.75
2...........	Eagle Grove—Boone	137,102.17
3...........	Manson—Iowa Falls—Madrid	125,796.03
32...........	All	105,066.28
	200 cases—20,000 layers—weekly	
1...........	Webster City	$150,023.74
2...........	Clarion—Boone	130,440.14
3...........	Humboldt—Iowa Falls—Boone	114,493.09
32...........	All	89,589.09
	200 cases—existing—twice weekly	
1...........	Webster City	$675,912.78
2...........	Clarion—Boone	628,690.70
3...........	Humboldt—Iowa Falls—Boone	590,301.48
32...........	All	530,605.30
	200 cases—1,000 layers—twice weekly	
1...........	Webster City	$360,548.80
2...........	Clarion—Boone	320,450.40
3...........	Humboldt—Iowa Falls—Boone	288,352.60
32...........	All	238,527.14

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